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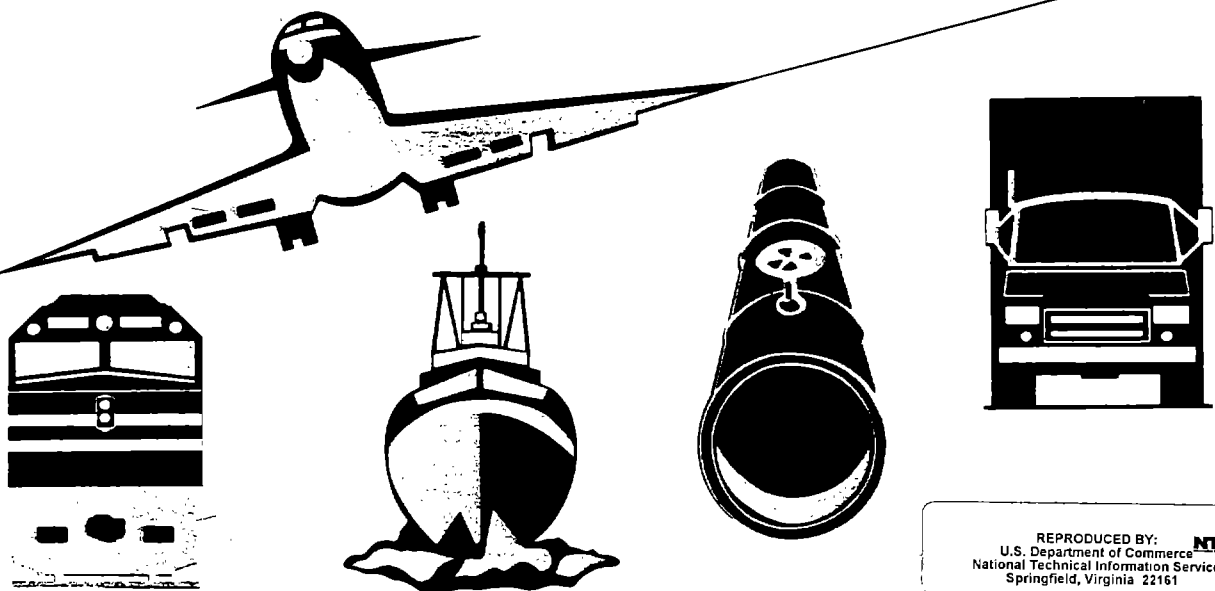
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NATIONAL TRANSPORTATION SAFETY BOARD

TRANSPORTATION SAFETY RECOMMENDATIONS

ADOPTED DURING THE MONTH
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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: January 15, 1998

In reply refer to: A-98-1 and -2

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On April 3, 1997, about 1948 eastern standard time, a Cessna 650 (Citation III), N553AC, operated by Mercury Communications, experienced an in-flight fire while on approach to the Greater Buffalo International Airport in Buffalo, New York. While descending through 4,000 feet, the crew smelled smoke, a navigation display went blank, and radio communications were lost. After an emergency landing, ground personnel saw flames burning through a hole in the aft fuselage and informed the crew. The flightcrew and passenger evacuated with no injuries; however, the airplane was substantially damaged. The flight was being conducted under the provisions of Title 14 Code of Federal Regulations Part 91 as a corporate flight from Wellsville, New York, to Buffalo.

The Safety Board's investigation revealed that the fire was caused by arcing between 115VAC electrical wiring and the hydraulic pump suction line in the area above the baggage compartment. A fleetwide inspection of Cessna 650s found that nine airplanes had electrical wiring chafing against the same hydraulic line and were at risk of a similar in-flight fire. A subsequent Federal Aviation Administration (FAA) airworthiness directive (AD) required all Cessna 650s to be modified with the installation of an additional clip and five clamps with associated hardware to ensure positive separation between the electrical wires and the hydraulic line.

The Safety Board is aware of other recent incidents caused by inadequate clearance between electrical wiring and adjacent components. On June 25, 1996, Delta Air Lines flight 148, a Boeing 767-300ER (767), experienced a flight control malfunction after taking off from John F. Kennedy International Airport, Jamaica, New York. While climbing through 5,000 feet, the captain heard a loud pop, and the airplane banked sharply to the left. The flightcrew had to deflect the control wheel 25° to the right to maintain a level attitude; a successful emergency landing was made back in New York. The Safety Board's investigation revealed that an aileron flight control cable failed as a result of arcing when it contacted adjacent electrical wiring. Several days later, an aileron cable failure occurred on a 767 operated by Lan-Chile Airlines under similar circumstances. The FAA

issued a telegraphic AD for a fleetwide inspection to ensure that 1 inch of clearance existed between the flight control cable and the electrical wiring.

The Safety Board also learned of a 1995 incident aboard a Japan Air Lines (JAL) 767 in which inadequate clearance led to arcing between electrical wiring and an oxygen line fitting near the captain's oxygen mask. This incident was followed by a Boeing service bulletin and an FAA AD mandating the installation of protective sleeving over the wiring within 2 inches of the oxygen lines as an interim protective measure. A July 2, 1997, proposed AD calls for permanent modifications to ensure adequate clearance between oxygen equipment and adjacent wiring.

Based on these accidents/incidents, the Safety Board performed a review of the FAA guidelines for safe wire routing practices. Guidelines were found in two references, Advisory Circular (AC) 43.13-1A, "Acceptable Methods, Techniques, and Practices-Aircraft Inspection And Repair," and AC 65-15, "Airframe and Powerplant Mechanics Airframe Book." (The Safety Board recognizes that these advisory circulars provide general wire routing guidelines and that more specific guidelines may be provided by the manufacturer.) These references state that no electrical wire should be located within 1/2 inch of any combustible fluid or oxygen line, and if the separation is less than 2 inches, back-to-back clamps or a polyethylene sleeve should be installed to ensure positive separation. They also state that electrical wiring should be routed to maintain clearance of at least 3 inches with any control cable. If this clearance cannot be maintained, mechanical guards should be installed to prevent contact between the wiring and the control cables.

The Safety Board reviewed the current company standards and practices used by several manufacturers and found that they do not always provide for the clearance around electrical wiring recommended in the FAA guidelines. For example, Cessna's process specification, "Wiring Installation for Commercial Aircraft," states that wiring shall not be attached to hydraulic lines, and that wiring within 6 inches of hydraulic lines must be firmly supported. However, it does not mention using back-to-back clamps or a polyethylene sleeve to ensure positive separation if the separation is less than 2 inches. Design drawings for the Cessna 650 specify 1/2 inch of clearance between the hydraulic line and electrical wiring but provide no means to ensure positive separation. The Safety Board recognizes that after the Buffalo, New York, accident, the FAA issued an AD to mandate the installation of additional clamps on all Cessna 650s to ensure positive separation. However, the Board is concerned that Cessna's design drawings for the Cessna 650 were not consistent with Cessna's process specifications nor the FAA's guidance.

The Boeing Standard Wiring Practices Manual states that electrical wiring should be routed at least 3 inches away from control cables, if possible. If this cannot be done, rigid support of the wiring must be specified, and if necessary, special mechanical or electrical protection between wiring and control cables should be specified. However, design drawings for the 767 specify only 1 inch of separation between the aileron flight control cable and adjacent electrical wiring, with no mechanical or electrical protection specified; this 1 inch separation did not prevent arcing in the Delta Air Lines and Lan-Chile Airlines incidents. A Boeing service letter and subsequent AD

issued after these incidents still require only 1 inch of clearance in this area, with no mechanical guards to prevent contact as recommended in the referenced FAA guidelines.

Finally, the original design of the 767 flightcrew oxygen mask stowage box allowed for electrical wiring to be within 2 inches of oxygen lines, with no protective sleeving over the wiring, as recommended in the referenced FAA guidelines. However, following the 1995 JAL incident, a service bulletin and AD were issued requiring the installation of protective sleeving over the electrical wiring.

The Safety Board concludes that, although not mandated, the FAA guidelines provide adequate protection from the hazards associated with inadequate clearance between electrical wiring and adjacent components. However, the Board is concerned that manufacturers do not always provide this level of protection through their design standards or manufacturing and inspection processes. In some cases, manufacturers are required to modify designs to bring them in line with the FAA guidelines only after an in-service problem or an accident or incident has occurred. To minimize the risks associated with inadequate clearance around electrical wiring, the Safety Board believes that the FAA should review the design, manufacturing, and inspection procedures of aircraft manufacturers, and require revisions, as necessary, to ensure that adequate clearance is specified around electrical wiring, in accordance with published FAA guidelines. In addition, the FAA should review the existing designs of all transport-category airplanes to determine if adequate clearance is provided around electrical wiring, in accordance with published FAA guidelines. If deviations are found, require that modifications be made to ensure adequate clearance.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Review the design, manufacturing, and inspection procedures of aircraft manufacturers, and require revisions, as necessary, to ensure that adequate clearance is specified around electrical wiring, in accordance with published FAA guidelines. (A-98-1)

Review the existing designs of all transport-category airplanes to determine if adequate clearance is provided around electrical wiring, in accordance with published FAA guidelines. If deviations are found, require that modifications be made to ensure adequate clearance. (A-98-2)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:


Jim Hall
Chairman



National Transportation Safety Board

Washington, D.C. 20594
Safety Recommendation

Date: January 21, 1998
In reply refer to: A-98-3 through -5

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 12, 1997, at 1529 eastern daylight time, an Airbus Industrie A300B4-605R, N90070, operated by American Airlines as flight 903, experienced an in-flight upset at an altitude of 16,000 feet near West Palm Beach, Florida. During the upset, the stall warning system activated, the airplane rolled to extreme bank angles left and right, and rapidly descended more than 3,000 feet. One passenger sustained serious injuries, and the airplane received minor damage. Flight 903 was being conducted under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121 as a domestic, scheduled passenger service flight from Boston, Massachusetts, to Miami, Florida.

Although the cause of the in-flight upset is still under investigation, the Safety Board has identified several safety issues that it believes the Federal Aviation Administration (FAA) should address.

The A300 is equipped with an electronic flight instrument system (EFIS) that includes two primary flight displays (PFDs), which present airspeed, altitude, attitude, and other information needed to control the airplane, and two navigation displays (NDs), which present heading and other information needed to navigate. These displays are controlled by symbol generator unit (SGU) computers, which process inputs from the various sensors and format the data for display.

During the upset, the captain stated that the EFIS displays were lost for "2 to 3 seconds" and that they were replaced by a white diagonal slash mark across the display screens. This loss of EFIS displays left only the standby indicators available for attitude, airspeed, and altitude reference. The first officer stated that the loss of EFIS displays occurred "when the situation was at its gravest."

Airbus Industrie informed the Safety Board that the diagonal slash marks displayed on the screens during the upset indicated that the SGUs were undergoing an automatic reset and self-test involving software that is designed to detect unreliable data. For example, the SGUs monitor changes in the airplane's flight parameters, such as roll angle, pitch angle, and airspeed. If any of these parameters change at a rate that exceeds a predetermined threshold value, an SGU reset occurs that

allows the SGU to perform a self-test for several seconds to determine if the excessive rate-of-change is the result of unreliable data.

The Safety Board learned that the threshold for triggering an automatic reset can be reached during an in-flight upset. For example, if the roll angle rate of change is more than 40° per second, a reset will occur. According to data from the flight data recorder (FDR), flight 903 experienced a change in roll angle in excess of 40° per second during the upset.

The Safety Board is concerned that the loss of all primary flight information during an upset can critically affect a flightcrew's ability to recover the airplane. According to Airbus Industrie, this is the first instance in which an SGU reset was reported during an upset. However, the Safety Board has investigated numerous upsets¹ on large, transport-category airplanes and has a longstanding concern about the need for air carrier pilots to receive training in the recognition of and recovery from unusual attitudes and upsets. In its advanced aircraft maneuvering program, American Airlines teaches pilots (including A300 flightcrews) to recognize various unusual attitudes on their primary flight displays. Loss of information from these displays could adversely affect recognition and recovery from unusual attitudes.

The Safety Board realizes that the intent of the automatic reset feature is to prevent the display of erroneous data to the flightcrew; however, it is concerned that the threshold values selected for activating this feature cause a reset to occur when accurate data is being displayed during an upset. This results in the loss of all primary flight displays at a time when pilots need their critical information the most. Therefore, the Safety Board believes that the FAA should require that Airbus Industrie modify the SGU computer software installed in the A300 so that an unreliable data reset of the EFIS will not occur during an upset. When the modified software is available, the FAA should require that all operators install it in the SGUs.

The effect of SGU failure on the PFDs is outlined in the emergency and abnormal procedures section of the American Airlines A300 Operating Manual. Thus, pilots should recognize that the diagonal slash on EFIS displays results from SGU failure. However, conditions such as the roll rate limitation that produce an SGU failure are not addressed, and the potential for EFIS displays to go blank during maneuvering is not presented in the chapter on unusual attitude recovery. Knowing that the EFIS displays might go blank for several seconds during an upset will better prepare pilots to transfer rapidly to standby instrumentation if an SGU reset occurs during maneuvering. Therefore, as an interim action, the Safety Board believes that the FAA should issue a flight standards information bulletin to direct principal operations inspectors to ensure that A300 operators notify flightcrews of the possibility of a temporary loss of EFIS displays during an upset.

¹National Transportation Safety Board. 1996. *In-flight Icing Encounter and Loss of Control, Simmons Airlines, d.b.a. American Eagle Flight 4184, Avions de Transport Regional (ATR) Model 72-212, N401AM, Roselawn, Indiana, October 31, 1994*. NTSB/AAR-96/01. Washington, D.C.; National Transportation Safety Board. 1992. *Uncontrolled Collision with Terrain for Undetermined Reasons, United Airlines Flight 585, Boeing 737-291, N999UA, Colorado Springs, Colorado, March 3, 1991*. NTSB/AAR-92/06. Washington, D.C.; National Transportation Safety Board. February 20, 1997. Safety Recommendation Letter. Recommendations A-97-16 through -18.

Another issue raised in this investigation involves the A300 autothrottle system (ATS). The A300 is equipped with an ATS that provides automatic thrust control and can be selected during any flight phase. The ATS can be engaged in several modes, including the speed/Mach mode in which thrust is controlled to maintain the airspeed or Mach number selected by the flightcrew. The ATS is normally engaged via the "A/THR" (automatic throttle) button on the glareshield flight control unit panel. When this button is depressed, three green bars illuminate in it, and the amber "MAN THR" (manual thrust) legend on the flight mode annunciator section of the PFDs is replaced by a green legend corresponding to the selected ATS mode.

Both flightcrew members stated that the ATS was engaged and set to hold an airspeed of 210 knots at the time of the upset. FDR data indicate that the ATS was engaged at the onset of the descent from 24,000 feet. During the descent, the flightcrew moved the power levers from the ATS idle thrust setting to the throttle control lever mechanical stops, slightly reducing the thrust. [This technique is common among A300 crewmembers since it allows the airplane to descend more quickly, and it can be done either with or without disengaging the ATS.] However, when the pilot leveled off at 16,000 feet, FDR data indicate that the ATS was not engaged and that the airspeed began to decrease. As the airplane slowed to about 170 knots, the flightcrew rapidly advanced the throttles, but the stall warning activated and the in-flight upset occurred. Postflight testing found no evidence of ATS malfunction. The Safety Board is concerned that the airplane might have been allowed to decelerate well below the intended airspeed because the flightcrew believed that the ATS was still engaged when it was not.

There are a variety of ways that the ATS can be disengaged when a flightcrew wants manual control of engine thrust. The most common method is to depress the ATS disconnect button on either throttle. This gives the flightcrew manual control of the throttles and causes the ATS mode displayed on the PFD to change to an amber MAN THR indication, and the three green bars in the A/THR button to extinguish.

However, other transport-category airplanes similar to the A300 have been designed with warning systems that require additional flightcrew action to help ensure flightcrew awareness of autothrottle disconnect. For example, after depressing the ATS disconnect button on the McDonnell Douglas MD-11, the ATS disconnects, but a flashing, red "ATS OFF" legend appears on the PFD. This flashing legend continues until the ATS disconnect button is depressed a second time. Other airplanes, such as the Douglas DC-10, MD-80, Boeing 737 (B-737), and Fokker F-100, are designed in a similar fashion. Airplanes, such as the B-757, B-767, and B-777, also sound an aural alert that continues until the flightcrew confirms that they have manual control of the throttles by depressing one of the ATS disconnect buttons a second time.

The A300 indications of autothrottle disconnect are of a passive, persistent nature (an amber MAN THR legend on the PFD and the absence of three green bars in the A/THR button). The Safety Board recognizes that these cues can function as a warning; however, their persistent quality is more typical of an information display and does not command attention. Since pilot attention typically is not drawn to these persistent cues, it is possible for a delay to exist between inadvertent autothrottle disconnect and flightcrew recognition of the event. In contrast, warnings that use flashing displays,

aural alerts, or that require positive action to silence, function to capture flightcrew attention and help ensure recognition. Therefore, in light of this accident, the Safety Board believes that the FAA should compare the design of the A300 autothrottle system with similar transport-category airplanes, and determine if additional visual/aural warnings are necessary to ensure that flightcrews are aware that they have manual control of the throttles. If additional warnings are necessary, Airbus Industrie should be required to modify the A300 accordingly.

Therefore, the Safety Board recommends that the Federal Aviation Administration:

Require that Airbus Industrie modify the symbol generator unit (SGU) computer software installed in the A300 so that an unreliable data reset of the electronic flight information system will not occur during an upset. When the modified software is available, require that all operators install it in the SGUs. (A-98-3)

Issue a flight standards information bulletin to direct principal operations inspectors to ensure that Airbus Industrie A300 operators notify flightcrews of the possibility of a temporary loss of electronic flight instrument system displays during an upset. (A-98-4)

Compare the design of the A300 autothrottle system with similar transport-category airplanes, and determine if additional visual/aural warnings are necessary to ensure that flightcrews are aware that they have manual control of the throttles. If additional warnings are necessary, Airbus Industrie should be required to modify the A300 accordingly. (A-98-5)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: 
Jim Hall
Chairman